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Genetic Evaluation of Pekin, Nageswari and Pekin × Nageswari Crossbred Duck for Growth and Egg Production Traits Under Intensive Management Condition

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Abstract

Duck is an important genetic resource primarily used for egg and meat in Bangladesh. This study evaluated the growth performance and egg production potentials of Pekin (P) × Nageswari (N) crossbred ducks compared to its parental Pekin and Nageswari breeds. The growth performance data of 440 P×N crossbreds were collected from three generations (F_1, F_2, and F_3), while the first two generations' data on productive and reproductive traits were considered. Besides, performances of parental Pekin and Nageswari ducks (100 from each breed) were included in the evaluation process. The growth performance significantly differed among the Pekin, Nageswari and P×N crossbreds from day old to the 12th week of age ($P < 0.001$). The average live weight of the Nageswari duck was 1367 ± 17.38 g at the 12th week of age and was 1703.02 ± 19.76, 1910.46 ± 18.81 and 1826.49 ± 20.63 g, respectively, in F_1, F_2 and F_3 crossbreds that close to the parental Pekin duck (1908.26 ± 34.18 g). Growth performance was superior in all three crossbred generations up to the 12th week of age except day old. The positive heterosis varied from 3.86 to 15.64% at marketing age (12th week). The P×N crossbreds attained sexual maturity two weeks earlier than the Pekin duck. The hen day egg production (HDEP%) was significant ($P < 0.01$) among the genotypes up to the 40th week of age except the 28th week. The total number of eggs up to 280 days in Pekin, Nageswari and two P×N crossbred F_1 and F_2 generations were 90.54, 92.32, 86.61 and 94.08, respectively. The egg weight of parental pure breeds and P×N crossbreds differed significantly ($P < 0.05$) during the investigated periods from the 24th to the 40th week of age. This result reflects the significance of non-additive genetic effects on growth traits. In conclusion, the genetic evaluation involving three generations of data essentially helps to establish the performances of the developed P×N crossbred duck.

Introduction

Ducks (*Anas platyrhynchos*) are popular poultry species in many developing countries including Bangladesh, because of their attributes like good foraging ability, longer productive life and better disease resistance. In Bangladesh, duck stands second after chicken, used for egg and meat production. The total duck population in Bangladesh is about 66.02 million (DLS, 2023). According to FAOSTAT (2020), ducks account for about 10% of total poultry meat production in Asia, compared to only 4.1% globally. Irrespective of religion, duck meat is famous in the Bangladeshi community despite its demand fluctuating based on seasons. Small-scale duck farming can potentially improve the nutritional status, food security, and household income for women in Bangladesh. Farmers used to rear several ducks with their chickens as part of traditional husbandry practices across the country, except in the northeastern wetlands and coastal regions, where

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large-scale flocks consisting of hundreds to thousands are discernable (Bhuiyan *et al.*, 2017). Several exotic duck breeds like Khaki Campbell, Jinding, Indian Runner, and indigenous Nageswari have been raised,mainly for egg production in Bangladesh. The Nageswari (N) duck breed, native to Bangladesh, is known for its bluish-tinted eggs and completely black or pencil-black plumage, except for the white breast area. With approximately 200 eggs production per year, this breed is well suited to current management practices and agro-climate of Bangladesh (Morduzzaman *et al.*, 2015) (Bhuiyan *et al.*, 2017).

On the other hand, Pekin (P) ducks have a dual-purpose utility; they produce roughly 200 white eggs each year and aremainly used for meat worldwide (Padhi and Sahoo, 2012). However, their adaptation to the semi-scavenging environment of Bangladesh is a major obstacle to profitable duck farming (Ahmad *et al.*, 2021). Therefore, crossing between Pekin and Nageswari ducks would provide a platform to explore their egg and meat production capabilities in the situations described above.

Crossbreeding is practiced in different livestock and poultry species for rapid improvement of growth and production potentials by exploiting heterosis. Inter- and intra-species crossbreeding have been reported in ducks to improve production, meat quality, and reproductive efficiency traits (Matitaputty *et al.*, 2015; Ahmad *et al.*, 2021). Crossing Pekin with Local ducks increased meat output capacity in the resultant crossbreds (Ansary *et al.* 2008). According to Padhi and Sahoo (2012), direct genetic effects, maternal effects and heterosis were significant for all attributes at the 8th week of age in crossbreds between Khaki Campbell and White Pekin ducks. In addition, the crossbreds of Pekin and Muscovy ducks had significantly better growth performance and breast meat quality (Matitaputty *et al.*, 2015). Recent research found that crossing between Pekin and Nageswari ducks produced superior F_1 crossbreds for growth, morphometry and meat quality traits (Ahmad *et al.*, 2021). However, limited information was available on the growth and egg production ability of the crossbreds mentioned above utilizing multi-generation data. Therefore, the present study was designed to evaluate the growth performance, production and reproduction potentials of P×N crossbreds compared to parental Pekin and Nageswari ducks.

Materials and Methods

Establishment of experimental flocks

The study was carried out following the guidelines of the Animal Care and Use Committee of Bangladesh Agricultural University (BAU) and the protocol was approved by the Ethics Committee of BAU (No.: BAURES/2020 ESRC/AH/03). This experiment was conducted in 2019 at the poultry shed managed by the Department of Animal Breeding and Genetics, BAU, where the generation interval was 45 weeks/generation. To produce foundation stock, 100 pure Pekin and 100 pure Nageswari day-old ducklings were collected from the Regional Duck Breeding Farm, Naogaon and Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka, respectively. Individual selection was performed at the 10th and 16th week of age based on their growth performance, phenotypic features, and respective breed criteria. Finally, 8 males and 40 females from each pure breed were selected to develop foundation stocks. The crossbred F_1 ducklings were obtained through mating between the Pekin drake and the Nageswari duck. Then, *inter se* mating was performed among the individuals of F_1 and successive generations to reproduce F_2 and F_3 generations. Birds of each generation were included from the same hatch. The selection was practiced in every generation at the 16th week of age based on growth and morphological features. The selection criteria for live weights of male and female birds were fitted as 2.20 and 1.8 kg, respectively. Finally, 40-50 selected individuals with a 5:1 male-female ratio have been maintained until 42nd week of age to investigate their laying performance.

Husbandry Practices

Birds were reared on perch where every genotype was kept in a separate room. In every generation, four types of rations were provided during the experimental period. : The nutrition composition of the provided ration is in Table 1. During the first three weeks, commercial layer starter feed (Ag Agro Ltd., Bangladesh) was given twice daily (morning and afternoon). After that, handmade mash feed was given in the morning and afternoon and the feed requirement was adjusted based on dual-purpose duck breed. Ducks were vaccinated against duck plague, avian influenza and duck cholera. Drinking water was provided ad libitum twice daily and the feeder and waterers were cleaned daily before feed delivery in the morning. In the breeding flock, a male-to-female ratio of 1:5 was maintained. During laying time, the photoperiod was adjusted to 16 hours per day by providing artificial light and sufficient nest. Ducks were allowed to stay in the run for 2 to 3 hours (11.00 am to 2.00 pm) per day.

Table 1. Feed ingredient and nutrient composition of ration supplied to the experimental birds

	Starter (0-3 weeks)	Grower (4-17 weeks)	Pre-laying (18-19 weeks)	Laying (20-42 weeks)
Ingredient*				
Corn	UN[1]	50.00	51.00	51.00
Soybean meal	UN	25.00	18.00	18.00
Rice polish	UN	18.00	18.50	16.00
Fish meal	UN	2.50	4.00	5.40
Limestone	UN	1.60	5.00	6.00
Dicalcium phosphate	UN	2.00	2.40	2.50
Lysine	UN	0.25	0.30	0.30
DL-Methionine	UN	0.20	0.25	0.25
Vitamin premix	UN	0.20	0.30	0.30
Common salt	UN	0.25	0.25	0.25
Total (kg)	UN	100.00	100.00	100.00
Nutrient composition**				
ME (Kcal/kg)	2850	2750	2800	2800
CP%	22.00	16.50	17.00	17.50
Lysine	0.80	0.70	0.78	0.88
Methionine	0.40	0.29	0.32	0.50
Met + Cysteine	0.58	0.42	0.62	0.78
Calcium	1.10	1.00	2.75	2.95
Available Phosphorus	0.50	0.50	0.48	0.50
Common salt	0.25	0.25	0.25	0.25

*Supplied in kg

**ME= Metabolizable Energy; CP= Crude Protein

[1] UN = Unknown. A commercial layer starter feed (Ag Agro Ltd., Bangladesh) was used as a starter diet.

Traits measured

Data on growth, production and reproduction performances were recorded weekly . The live weight was measured every week in the early morning before replenishment of feed and water and continued until the 12th week of age. The following traits like age and weight at sexual maturity, egg production per day and egg weight were documented in the record sheet. The generated data were used to calculate hen day egg production (HDEP%), average egg weight (AEW), fertility and hatchability (%), egg mass production, and no. of eggs up to 280 days by the following formula:

$$\text{Hen day egg production (\%)} = \frac{\text{Total number of eggs produced in a week}}{\text{Total number of female ducks present in that week}} \times 100$$

$$\text{Average egg weight} = \frac{\text{Total weight of eggs laid in a day}}{\text{Total number of eggs weighed in a day}}$$

Egg mass production = HDEP (%) × Average egg weight in gram

$$\text{No. of egg production up to 280 days} = \frac{\text{Total number of eggs laid up to 280 days}}{\text{Total number of ducks}} \times 100$$

The superiority of progenies over both their parents in terms of growth performance was calculated using the formula;

$$\text{Heterosis(\%)} = \frac{\text{Crossbred average} - \text{Purebred average}}{\text{Purebred average}} \times 100$$

Statistical analyses

The generated data were accumulated in an Excel sheet of Microsoft Office 2019 from the record sheet kept during the trial time. After that, the data was sorted and extreme values beyond three standard deviations were excluded from the analysis. The variables were described using descriptive statistics, including mean, standard error, frequency, and percentage distribution. The Agricolae package in R was used to do an ANOVA with a completely randomized design (Mendiburu, 2021). The significant differences between means were tested by the pastecs package of R (Grosjean *et al.*, 2018). The genotype and generation of the birds were considered as fixed effects on the investigated traits and the effects were calculated using the following model;

$Y_{ijk} = \mu + G_i + F_j + (GF)_k + e_{ijk}$

Where,

Y_{ijk} = the dependent variable (traits);

μ = the overall mean;

G_i = the fixed effect of i[th] genotype (P, N, and PN crossbreds)

F_j = the fixed effect of jth generation (F_0, F_1, F_2 and F_3 generations)

$(GF)_k$ = the interaction effects between genotype and generation

e_{ijk} = the random residual error.

Results

Live weight and growth performance

Table 2 represents the growth performances of pure

Nageswari, Pekin, and P×N crossbreds of three successive generations under intensive management conditions up to the 12th week of age. Growth performances differed significantly among the studied genotypes ($P < 0.001$) where Pekin ducks consistently outperformed the two other genotypes. On the other hand, Nageswari attained the lowest live weight and crossbred ducks of three generations occupied the intermediate position significantly in most cases. Importantly, at marketing age (10th and 12th week), there were non-significant differences between Pekin and P×N crossbreds. The growth performances of Pekin, Nageswari and P×N crossbreds (F_1, F_2 and F_3 generations) at the 12th week of age were 1908.26 ± 34.18, 1367 ± 17.38, 1703.02 ± 19.76, 1910.46 ± 18.81 and 1826.49 ± 20.63 g, respectively. Figure 1 represents the heterosis of growth performances in P×N crossbreds up to the 12th week. All three crossbred generations showed negative hybrid vigor at day old.

Table 2. Growth performance of Pekin and Nageswari ducks and their crossbreds under intensive management conditions up to the 12th week of age[1]

Age	Pekin (P)	Nageswari (N)	P♂ × N♀ Crossbred			Level of sig[3].	Effect of G×G
			F_1	F_2	F_3		
Day-old	55.70^{a}±0.42 (89)[2]	49.46^{b}±0.54 (98)	41.35^{d}±0.41 (106)	44.35^{c}±0.38 (196)	43.04^{cd}±0.43 (139)	***	NS
1st week	168.95^{b}±1.89 (91)	112.41^{d}±1.39 (98)	152.05^{c}±1.83 (106)	179.55^{a}±2.50 (167)	148.31^{c}±2.38 (138)	***	*
2nd week	315.17^{a}±7.40 (79)	240.40^{c}±3.50 (98)	315.37^{a}±4.09 (106)	328.28^{a}±3.80 (193)	277.81^{b}±4.49 (137)	***	**
4th week	755.23^{a}±12.89 (79)	582.42^{c}±7.34 (98)	714.25^{a}±9.97 (106)	734.17^{a}±9.58 (193)	668.15^{b}±9.63 (137)	***	***
6th week	1220.40^{a}±20.95 (60)	798.73^{e}±12.21 (56)	883.80^{d}±12.90 (105)	1093.65^{b}±12.65 (196)	1017.60^{c}±14.41 (137)	***	NS
8th week	1556.10^{a}±23.05 (60)	1004.73^{e}±12.69 (56)	1228.90^{d}±19.25 (105)	1474.59^{b}±13.22 (193)	1404.24^{c}±17.93 (133)	***	NS
10th week	1770.74^{a}±28.90 (50)	1268.07^{d}±15.56 (45)	1525.58^{c}±19.43 (105)	1745.30^{a}±15.20 (193)	1667.06^{b}±19.05 (132)	***	NS
12th week	1908.26^{ab}±34.18 (50)	1367^{d}±17.38 (45)	1703.02^{c}±19.76 (105)	1910.46^{a}±18.81 (157)	1826.49^{b}±20.63 (132)	***	*

[1]Live weight in gram; F_1, F_2 and F_3 = Crossbred ducks of first, second and third generations, respectively.
[2]Values in the parentheses indicate the number of observations, G × G = Interaction effects between genotype and generation.
[3]Different superscripts in the same row differ significantly at $^{***}P < 0.001$.

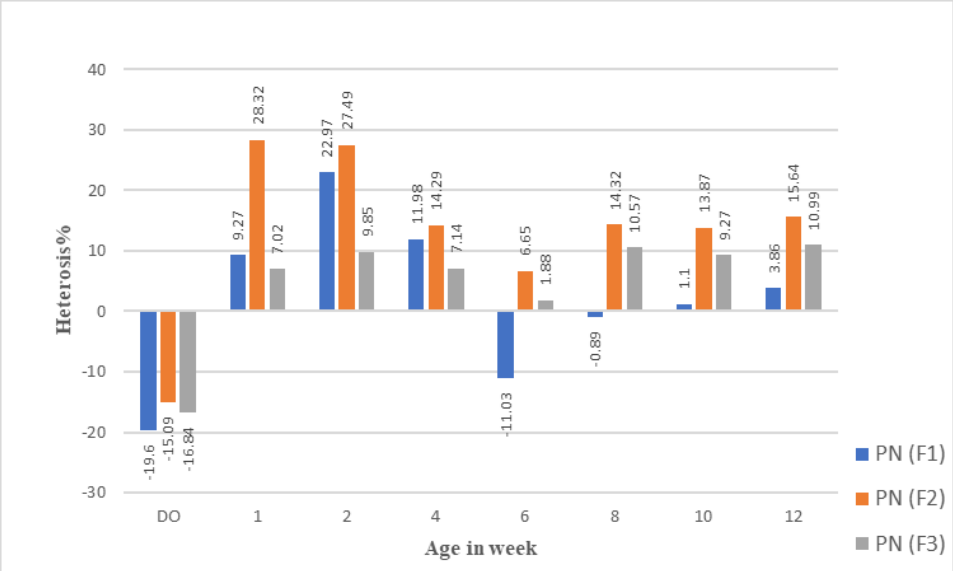

Figure 1. Heterosis (%) of growth performance in Pekin × Nageswari crossbreds up to 12th week of age

However, they showed superiority for the rest of the experimental period while maximum heterosis was obtained in F_2 generation. At marketing age, the positive heterosis was 3.86, 15.64 and 10.99% in the F_1, F_2 and F_3 generations, respectively.

Reproductive performances

Table 3 shows the reproductive performances of parental Nageswari and Pekin, and two crossbred generations. The age at 1st lay (AFE) of Pekin, Nageswari and the resultant crossbreds of F_1 and F_2 generations were 154, 137, 139, and 143 days, respectively. Pekin ducks attained sexual maturity two weeks later than Nageswari and crossbred ducks (Table 3). Notably, no significant difference was observed for this trait between Nageswari and crossbred ducks. Fertility rate (%) was 88.88, 86.49, 94.06 and 89.07, respectively, in Pekin, Nageswari and their F_1 and F_2 crossbreds. Hatchability (fertile egg basis) of the corresponding duck populations was found 62.50, 56.25, 67.37 and 62.65%, respectively. The characteristic bluish egg color of the Nageswari duck disappeared in the the crossbred duck populations.

Table 3. Reproductive performances of Pekin, Nageswari, and their crossbreds under intensive management condition

Trait*	Genotype			
	Pekin (P)	Nageswari (N)	P♂×N♀ (F_1)	P♂×N♀ (F_2)
Age at 1st laying (day)	154	137	139	143
Fertility (%)	88.88	86.49	94.06	89.07
Hatchability (fertile egg basis) %	62.50	56.25	67.37	62.65
No. of eggs up to 280 days/duck	90.54	92.32	86.61	94.08
Egg mass production (g/bird/day) up to 280 days	49.07	40.40	42.22	41.90
Egg color	Chalky white	Bluish	Chalky white	Chalky white

Productive performances

The productive performances of Nageswari and Pekin and the resultant F_1 and F_2 duck populations are shown in Tables 3 and 4. HDEP (%) differed significantly ($P < 0.01$) among the genotypes up to the 40th week of age except at the 28th week. Among the genotypes, the differences were maximum up to the 24th week of age. The peak of HDEP% was found at the 32nd week in Pekin, F_1 and F_2 crossbred populations, but at 24th week in Nageswari duck (Table 4). A persistent egg production (HDEP%) was observed in Pekin and the crossbred ducks, but it fluctuated largely in the Nageswari duck. The total egg numbers up to 280 days were 90.54, 92.32, 86.61, and 94.08, in Pekin, Nageswari, F1 and F2 crossbreds, respectively (Table 3) and did not differ significantly among the genotypes. The highest egg mass production (EMP) was recorded in the Pekin duck due to bigger bigger-sized eggs and as expected, the lowest EMP was found in the Nageswari duck. Among the genotypes, egg weight differed significantly ($P < 0.01$) at the 24th, 28th, 32nd, 36th and 40th week of age (Figure 2). The highest egg weight was found in Pekin ducks and was lowest in Nageswari ducks. The crossbred ducks laid -sized eggs, which were insignificantly different from Pekin ducks in most cases.

Table 4. HDEP (%) of Pekin, Nageswari and their crossbreds up to the 40th week under intensive management condition[1]

Age	Pekin (P)	Nageswari (N)	P♂ × N♀ Crossbred		Level of sig[3].
			F_1	F_2	
At 20th week	-	28.57^{a}±1.48 (35)	6.76^{b}±0.47 (25)	22.83^{a}±0.90 (33)	***
At 24th week	48.57^{c}±1.53 (35)	94.28^{a}±0.39 (35)	60.00^{b}±2.30 (25)	64.63^{b}±0.81 (33)	***
At 28th week	71.37^{a}±2.64 (35)	72.56^{a}±1.75 (35)	68.24^{a}±2.59 (25)	66.86^{a}±0.96 (28)	NS
At 32nd week	80.44^{a}±1.09 (35)	57.26^{b}±0.97 (35)	75.18^{a}±1.73 (24)	73.10^{a}±1.69 (28)	***
At 36th week	78.34^{a}±1.51 (35)	62.34^{b}±2.10 (34)	65.68^{b}±1.02 (24)	72.40^{ab}±2.56 (28)	**
At 40th week	70.41^{a}±1.12 (35)	65.30^{ab}±1.90 (34)	71.58^{a}±1.59 (24)	60.70^{b}±0.84 (28)	**

[1]HDEP= Hen-day egg production

[2]Values in the parentheses indicate the number of observations

[3]Different superscripts in the same row within a trait differ significantly at ***=$P < 0.001$, **=$P < 0.01$; NS= Non-significant ($P > 0.05$)

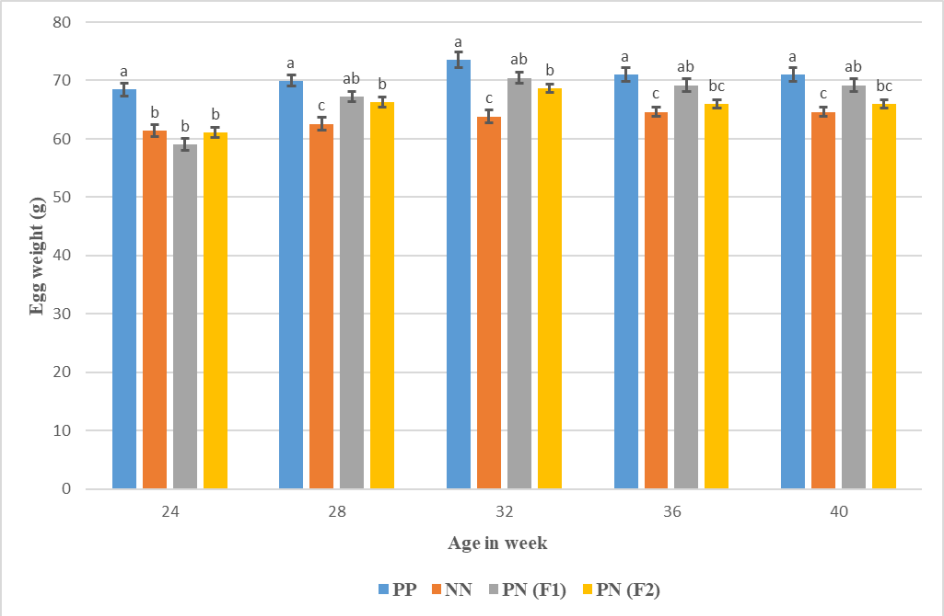

Figure 2. Average egg weight (g) of Pekin, Nageswari, and their crossbreds (F_1 and F_2) up to the 40th week of age

Discussion

Crossbreeding has been practiced in ducks to rapidly improve growth, adaptability and production potentials. Several previous studies pinpointed better heterosis effects for crossing between two established duck breeds (Khatun *et al.*, 2008; Makram *et al.*, 2021; Padhi and Sahoo, 2012). However, there is a lack of information on crossbreeding between Pekin and Indigenous ducks of Bangladesh (Nageswari). Similar to this study, Rahman *et al.* (2020) reported that the average body weight of Pekin ducks at day-old 7, 15, 30 and 60, and 90 days was 60.43 ± 2.08, 113 ± 2.65, 282.87 ± 9.26, 743.5 ± 26.48 and 1885 ± 34.56 g, respectively. Padhi and Sahoo (2012) stated that the average body weight of the crosses of Indigenous (D), Khaki Campbell (C) and White Pekin (P) ducks (D×C, D×P, C×D, C×P, P×D, and P×C) at the 8th week was 1220.87, 1841.26, 1341.04, 2053.35, 1799.55, and 1863.29 g and is comparable to the present findings. In another investigation, Bharali *et al.* (2019) found the mean body weight of a white Pekin duck at the 10th week of age as 2720.47±59.32 g under an intensive system, which wasrelatively higher than the present study. Bhuiyan *et al.* (2017) found the almost similar live weight of the Nageswari duck (1400.84±12.68g) at the 12th week of age under intensive management conditions. Higher live weight was reported by Morduzzaman *et al.* (2015) who found that the average live weight of Nageswari ducks at the 12th week of age was 1522.10 ± 129.35g. Ahmad *et al.* (2021) reported the average live weights of reciprocally produced F_1 crossbreds between Pekin and Nageswari at day old and 12th week of age were 46.52 ± 0.85 and 1851.85 ± 28.59 and 42.18 ± 0.48 and 1691.08 ± 27.80 g, respectively and is almost similar to this study. Ansary *et al.* (2008) reported the live weights of Pekin (P), P×Desi (D) and P×Jinding (J) crossbreds differed significantly ($P < 0.01$) up to 8 weeks of age and are in agreement with this study. They found the highest live weight in P, followed by those of P×D and P×J ducklings, respectively. It is notable to mention that crossbreeding experiment in ducks is not common practice like other livestock and poultry species, which limits comparing the present results comprehensively with earlier studies. However, the variations in growth rate at different stages might be associated with the differences in genotypes (selected or unselected populations), the plane of nutrition, the rearing system, quantity and frequency of feeding, etc.

In P×N crossbred ducks, almost positive heterosis effects were found for live weight trait up to the 12th week of age except for day-old weight which is in accordance with the previous findings of Padhi (2010) and Gorska *et al.* (2014) who reported significantly positive heterosis effects for live weight, morphometric and meat yield traits in the Pekin-derived crossbreds. Wolf and Knížetová (1994) reported that the average heterosis was 2.2% for body weight and the highest heterosis of 7.7%, which agrees with the present study. The crossbred chickens exhibited mostly varying degrees of positive heterosis effects for body weight at different ages ranging from -5.71 to 14.43%, which is supported by this study (Khalil *et al.*, 2018). In addition, Razuki and Shaheen (2011) and Siwendu *et al.* (2013) found positive heterosis (%) at all ages up to sexual maturity in the crossbred chickens except day old, which was negative that ranged from -2.03 to 39.58 and supports the current results. Similar to the present

investigation, earlier studies showed positive heterosis effects on body weight in crossbred ducks and chickens, however, the deviation in the magnitude of heterosis effects might be associated with the difference in the genetic composition of breeds, strains or populations, sample size, and selection practices.

In this study, the crossbreeds and Nageswari ducks attain sexual maturity nearly two weeks earlier than parental Pekin ducks. Padhi (2010) found that the AFE in Pekin duck was 148±4.61 day, comparable to this study. The AFE in Nageswari (156 days) ducks found to be lower than the reported values of Islam *et al.* (2016) and Morduzzaman et al. (2015), who found Nageswari ducks started to lay at the age of 183.60 and 168.48±3.53 days, respectively. Likewise, Zaman *et al.* (2005) recorded even higher AFE in Nageswari duck, which was 188 days with a range of 174-198 days under the scavenging condition. In general, AFE is a breed- or population-specific trait despite the quality and quantity of feed given to the birds, and managemental conditions may expedite the onset of lay to some extent. Fertility and hatchability of Pekin ducks were found to be (88.88 and 62.50%, respectively) higher than the reported values of Kırmızıbayraka *et al.* (2018), who obtained 70.04% fertility and 60.19% hatchability in Pekin duck. In another study, Padhi (2010) found the hatchability in Pekin duck was 47.50% based on total eggs, which is also lower than the present findings. Sharma *et al.* (2003) reported the hatchability ranged between 71.42 and 86.66% on total egg basis in Nageswari duck under natural hatching conditions and is higher than the results of this study. Fertility and hatchability are non-genetic traits that mostly depend on environmental factors like incubation system, nutrient content in the feed, age of the birds, male-female ratio, storage time of egg and cleaning of eggs before the incubation etc. and one or more factors might be associated for the discrepancy between previous and present study.

The HDEP% was calculated monthly starting from 20 weeks of age up to 40 weeks of age. Relatively higher HDEP% and earlier peak production were observed in this study compared to Bhuiyan *et al.* (2017) who found 55.67±2.74% average HDEP and peak production at 26th week of age in Nageswari duck. Khatun *et al.* (2008) reported the HDEP of the Nageswari duck was 55.40±2.36% under farmer's conditions in Bangladesh up to 52 weeks of age. Morduzzaman *et al.* (2015) found peak production one month later (29.46±0.19 week) than the present study in Nageswari ducks. The present finding on HDEP% in Pekin at the 40th week (70.41±1.12) is significantly higher than the reported value (58.30±4.62%) of Padhi (2010). In Kuzi ducks, 50% hen housed egg production was found at the 19th week of age (Padhi and Sahoo, 2012) that was significantly better than the reported values of this study. Breed or genotype differences might be one of the possible reasons for this discrimination. According to Lin *et al.* (2014), three Chinese duck breeds Shan Ma (S), Putian White (F), and Putian black (P) showed lower laying ability than the crossbred laying ducks F × (P × S) and F × (S × P) and agrees with the present findings. The disparity between current and prior findings could be attributed to a combination of factors including feed consumption (quality and quantity), light intensity and duration, age at first egg, parasite infestation, disease, and various management and environmental factors.

An increasing trend was observed in egg weight as the progression of age (Padhi, 2010) and is consistent with the present findings. The average egg weight (AEW) is comparable with the findings of Morduzzaman *et al.* (2015), Bhuiyan *et al.* (2017) and Phookan *et al.* (2018), who reported the AEW as 59.31, 58.20±1.50, and 61.04g, respectively in Nageswari ducks. Padhi and Sahoo (2012) found the AEW of Pekin duck was 71.96±0.39 and 75.81±0.88 g at the 36th and 40th week of age, respectively and is similar to the present study. Kavitha *et al.* (2017) reported that White Pekin duck eggs had a significantly ($P < 0.01$) higher egg weight than the Indigenous duck eggs which is consistent with this study. However, genetic makeup and age of the birds, rearing environment and plane of nutrition might be the attributing factors for differences in egg weight between present and previous studies.

The current research has uncovered some baseline information on growth, production and reproduction traits, particularly for the P×N crossbreds. The F1, F2 and F3 crossbredThe growth performances of F1, F2 and F3 crossbred growth performances were significantly higher than the parental Nageswari ducks but relatively lower compared to Pekin ducks up to the 12th week of age. Crossbred ducks showed their superiority in growth performances over the parental breeds. The HDEP% of crossbred ducks differed significantly with Nageswari ducks up to the 40th week of age except the 28th week. Notably, non-significant results were found between Pekin and crossbred ducks for egg production in most cases. The AEW varied significantly among the genotypes, where the crossbred ducks occupied an intermediate position. In conclusion, crossbreeding can offer additional benefits in growth traits compared to the purebreds without compromising egg production potentialities.

Conflict of interest

The authors declare no conflicts of interest with respect to the research and authorship.

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